WATERSHED BASED PLAN FOR THE ROBINSON RUN WATERSHED, MONONGALIA COUNTY, WEST VIRGINIA

DRAFT FOR EPA APPROVAL
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ABBREVIATIONS

Al	aluminum
ALD	anoxic limestone drain
AMD	acid mine drainage
AML	abandoned mine land
dis.	dissolved
Fe	iron
gpm	gallons per minute
L	liter
mg/L	milligrams per liter
Mn	manganese
MPPRP	Maryland Power Plant Research Project
MRB	manganese removal bed
NMLRC	National Mine Land Reclamation Center
NR	not reported
NRCS	Natural Resources Conservation Service
NTU	nephelometric turbidity unit
OAMLR	Office of Abandoned Mine Lands and Reclamation
OLC	oxic (or open) limestone channel
OSM	Office of Surface Mining, Reclamation and Enforcement
PA	problem area
PAD	problem area description
RAPS	reducing and alkalinity producing system
SRG	Stream Restoration Group
TMDL	total maximum daily load
tot.	total
ug/L	micrograms per liter
UMRA	Upper Monongahela River Association
UNT	unnamed tributary
USEPA	United States Environmental Protection Agency
WCAP	Watershed Cooperative Agreement Program
WVDEP	West Virginia Department of Environmental Protection
Zn	zinc

1. INTRODUCTION

Robinson Run is a small tributary that drains approximately 7.7 square miles of Monongalia County, across the Monongahela River and downstream from Morgantown, West Virginia (Figure 1). Robinson Run and two tributaries—Crafts Run and an unnamed tributary—are polluted by acid mine drainage (AMD) from old coal mines. A TMDL, completed in 2002, calls for substantial reductions of AMD discharges to return Robinson Run to health (USEPA, 2002). This Watershed Based Plan has been written to allow incremental Section 319 funds to be spent in the Robinson Run watershed to clean up discharges from coal mines abandoned before 1977, which are considered nonpoint sources of pollution.

This plan focuses on AMD—by far the most significant water quality problem in the watershed—and documents every known nonpoint source of AMD. Where data allow, costs of remediating each site are calculated. This plan also addresses technical and financial assistance needs, proposes an implementation schedule with milestones and measurable goals, and suggests an outreach and education program that will help make this plan a reality.

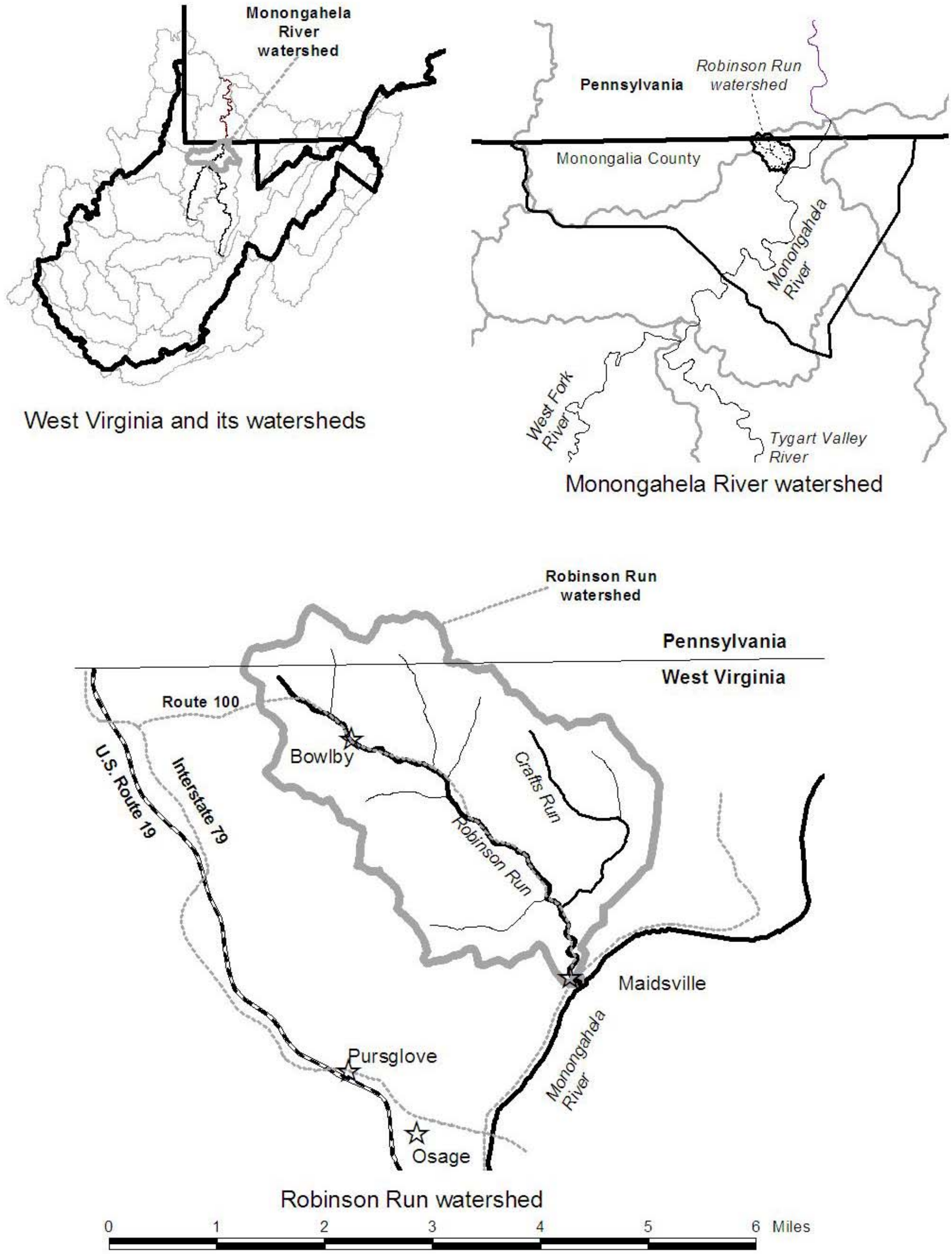
1.1 Background

The Robinson Run watershed and the surrounding area on the west side of the Monongahela River have supported a significant amount of coal mining for decades. Coal mining operations—including surface and underground mines, preparation plants, refuse areas, and coal loading facilities for transport on the Monongahela River—are still active today. This mix of old abandoned coal mines and newer, active operations makes the watershed somewhat unique, and presents possibilities for financing nonpoint source AMD clean-ups that would typically fall entirely on government agencies in watersheds where active mining operations are absent.

According to Ross's (1994) history of the local area, pioneer geologist William Barton Rogers, in conducting the first systematic inventory of mineral resources of the state of what was then Virginia, arrived at Morgantown in 1836, crossed the Monongahela River, and journeyed up Scotts Run, adjacent to the Robinson Run watershed. The Rogers survey found several fine beds of coal, including the "Main Coal" of northern Virginia, now known as the Pittsburgh seam. Rogers' team also found the Redstone, Sewickley, and Waynesburg seams.

The demand for coal during World War I stimulated the development of these coal seams. Annual production in Monongalia County reached 400 thousand tons in 1914 when the Monongahela Railway arrived on the west side of the Monongahela River, opposite from Morgantown (Ross, 1994). These tracks passed through the mouth of the Robinson Run watershed.

Figure 1: Location of the Robinson Run watershed



In 1913, the North American Coal Company opened its Maidsville mine under the Robinson Run watershed. Several smaller Pittsburgh seam mines began operation nearby (Ross, 1994). Sewickley coal from the area was also much sought after. According to Dr. Israel C. White, a Monongalia County native and West Virginia State Geologist:

> “But what shall we say of Morgantown's future, where a fourth coal of commercial thickness is added by dame nature to the three which Fairmont possesses, and these four at the height of their development in thickness and purity! It is the presence of these four splendid coal seams . . . that has brought about the most wonderful coal development . . . that the entire Appalachian field has ever witnessed.
>
> “. . . The Sewickley coal [in this region] . . . has a peculiar physical structure which renders it even more efficient as a fuel than even the Pittsburgh coal at its best, viz., the richly bituminous layers of the coal are separated by many layers of mineral charcoal one-sixteenth to one-quarter-inch thickness, often termed ‘mother coal’ by the miners. This composition prevents fusion of the coal on the grate bars and hence it burns up without clinker into a fine ash. . . . The Empire State Express of the New York Central Line, one of the fastest trains in the world, is reported to use this coal exclusively when available. It attains its maximum development in both purity and thickness in the Scott’s and Robinson’s Run regions, near Morgantown, often having a thickness of seven feet of clean coal with a splendid roof, while the great Pittsburgh bed, only 100 feet lower, has a thickness of eight and often nine feet. . . .” (Ross, 1994)

Hundreds of thousands of tons of coal were mined from the Maiden mines under the Robinson Run watershed through much of the twentieth century (West Virginia Department of Mines, Various dates).

1.2 Land use/land cover

As shown in Figure 2 and Table 1, the watershed is approximately half forested. One-third of the land has been used in mining. Pasture and agricultural land, residential land, and road corridors make up less than one tenth of the watershed each. There is a small amount of open water in the upper part of the watershed.

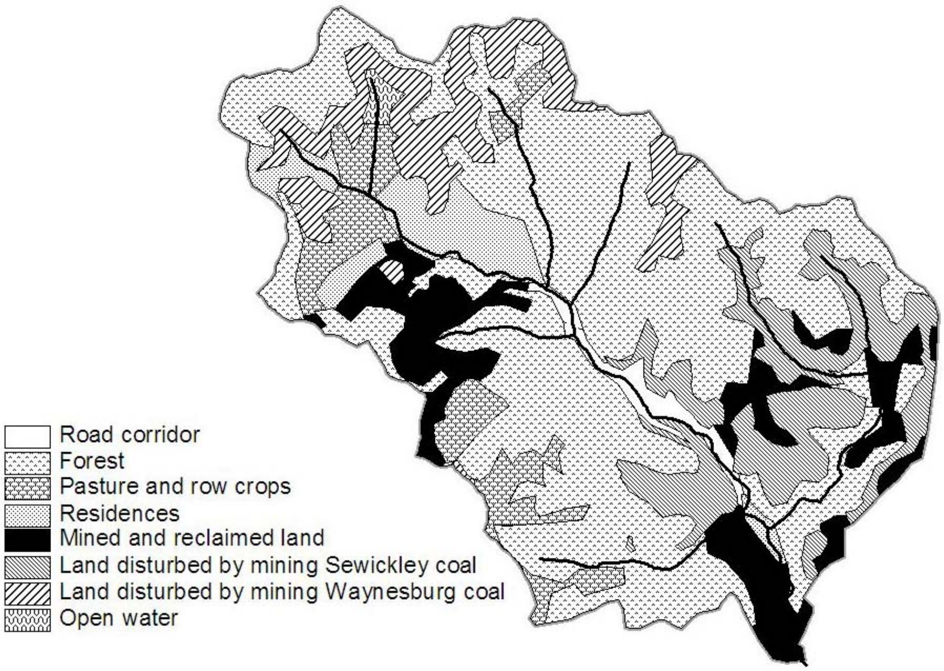
1.3 Geology

Figure 3 represents the structural contours of six coal seams that are mined in or near the Robinson Run watershed. The elevations were calculated along a transect (Figure 4) using data from the Coal Bed Mapping Project (WVGES, 2003) and from the USGS 7.5 minute topographical quadrangles (WVDEP, 2005c). The transect follows the steepest slopes of the coal seam, and passes through the Maiden #1 discharge, the most important AMD source in the watershed and a focus of this plan.

The six coal seams fall into two distinct groups. The lower three—the Pittsburgh, Redstone, and Sewickley seams—intersect the surface at outcrops in the lower part of the watershed. The upper three—the Waynesburg, Waynesburg A, and Washington seams—appear in the upper portion of the watershed. The two uppermost seams also have outcrops just to the west of the Robinson Run watershed. The Waynesburg seam also lies near the surface to the west. There are no down-gradient outlets for the lower three seams, however. These seams are therefore likely to hold pools of AMD, whereas the upper three seams should drain to the west of the watershed.

The Pittsburgh coal seam and its mine pools have been studied extensively by Ziemkiewicz et al. (2004). As groundwater leaches into the closed mines, the pool of water in the mines is rising, and will eventually discharge to the Monongahela River or its tributaries. These mine pools are discussed in more detail in Section 3.3.

Figure 2: Land use/land cover map of the Robinson Run watershed



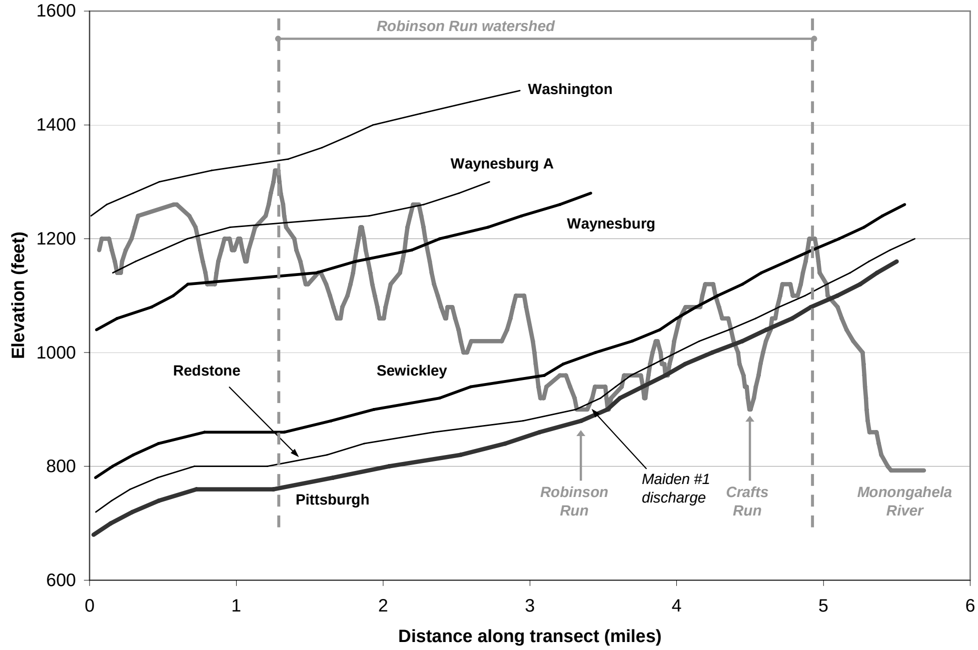
Source: Estimates of coverages were obtained from U.S. Geological Survey 7.5 minute topographical quadrangles (WVDEP, 2005c) and from digital orthophoto quadrangles (WVDEP, 2005d). Land disturbed by mining specific coal seams was estimated as areas of disturbed land near the appropriate seams on the topographical maps. Other mined and reclaimed land was estimated as areas of mined or reclaimed land on the orthophotos, which were not indicated on the topographical maps.

Table 1: Land use/land cover in the Robinson Run watershed

Land use	Subcategory	Acreage	Percent
Forest		2,495	51%
Mined land	Disturbed by mining Sewickley coal	637	13%
	Disturbed by mining Waynesburg and Waynesburg A coal	444	9%
	Other mined and reclaimed land	545	11%
	Subtotal, Mined land	1,626	33%
Pasture and agricultural land		377	8%
Residential		289	6%
Road corridor		94	2%
Water		24	0.5%
Total		4,905	100%

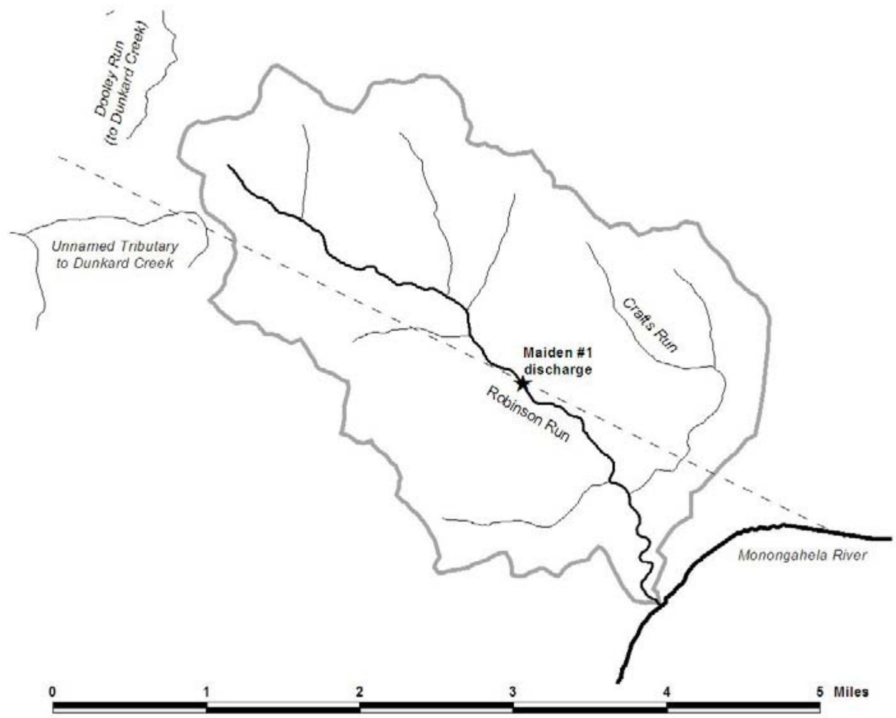
Source: Acreages are from Figure 2. Total percent does not sum to 100% due to rounding.

Figure 3: Coal seams in the Robinson Run watershed



Source: Coal structure was determined from data contained in the Coal Bed Mapping Project (WVGES, 2003). Surface contours were taken from USGS 7.5 minute topographical quadrangles (WVDEP, 2005c).

Figure 4: Location of geological transect



2. MEASURABLE WATER QUALITY GOALS

The federal Clean Water Act, state Water Pollution Control Act, and federal and state regulations have determined a set of interlinked water quality goals. Designated uses for the streams in the Robinson Run watershed include public water supply (Category A), maintenance and propagation of aquatic life (warm water fishery streams) (Category B1), and water contact recreation (Category C). The numeric and narrative water quality standards shown in Table 2 are relevant for the nonpoint source pollution problems addressed by this Watershed Based Plan. A fourth use—maintenance and propagation of aquatic life (trout waters) (Category B2)—is included in Table 2 for completeness, even though the impaired streams in this watershed are not designated as trout waters.

Table 2: Selected West Virginia water quality standards

		Aquatic life		**Human health**	
Parameter	**Section**	**Category B1 (Warm water fishery streams)**	**Category B2 (Trout waters)**	**Category A (Public water supply)**	**Category C (Water contact recreation)**
Aluminum (dissolved)	8.1	Not to exceed 87 µg/L (chronic) or 750 µg/L (acute)		None	None
Biological impairment	3.2.i	[N]o significant adverse impact to the…biological [component] of aquatic ecosystems shall be allowed.			
Fecal coliform	8.13	None	None	Maximum allowable level of fecal coliform content for Primary Contact Recreation (either MPN or MF) shall not exceed 200/100 ml as a monthly geometric mean based on not less than 5 samples per month; nor to exceed 400/100 ml in more than ten percent of all samples taken during the month.	
Iron (total)	8.15	Not to exceed 1.5 mg/L (chronic)	Not to exceed 0.5 mg/L (chronic)	Not to exceed 1.5 mg/L	None
Manganese (total)	8.17	None	None	Not to exceed 1.0 mg/L	None
pH	8.23	No values below 6.0 nor above 9.0. Higher values due to photosynthetic activity may be tolerated.			
Turbidity	8.32	No point or non-point source to West Virginia's waters shall contribute a net load of suspended matter such that the turbidity exceeds 10 NTUs over background turbidity when the background is 50 NTU or less, or have more than a 10% increase in turbidity (plus 10 NTU minimum) when the background turbidity is more than 50 NTUs.			
Zinc (dissolved)	8.33	Not to exceed chronic and acute concentrations that vary with hardness		None	None

Source: 46 Code of State Rules Series 1. Sections refer to this rule. When the TMDL was approved, the manganese criterion applied to all waters. USEPA has recently approved a modification to this criterion: "The manganese human health criterion shall only apply within the five-mile zone immediately upstream above a known public or private water supply used for human consumption." When the TMDL was approved, an acute total aluminum criterion of 750 µg/L was in effect. Since then, the aluminum criterion was changed to dissolved aluminum, and a chronic criterion was added. Also, the chronic dissolved aluminum criterion of 87 µg/L has been suspended in all but trout waters until July 2007. USEPA has still not approved or disapproved this suspension. The chronic dissolved zinc equation is: $Zn = e^{(0.8473[\ln(hardness)]+0.7614)} \times 0.986$. The acute dissolved zinc equation is: $Zn = e^{(0.8473[\ln(hardness)]+0.8604)} \times 0.978$. See Sections 8.32 and 8.32.1 for special circumstances for the turbidity standard. NTU = nephelometric turbidity unit.

As explained in the notes for Table 2, the aluminum and manganese criteria have become more lenient since 2002, when the total maximum daily load (TMDL) for this watershed was approved. Therefore, the TMDL's aluminum and manganese load reduction requirements may be more stringent than required to meet current water quality standards.

3. SOURCES OF ACID MINE DRAINAGE THAT MUST BE CONTROLLED

Streams that do not meet water quality standards are placed on a statewide list of impaired streams called the 303(d) list. Improving water quality so that these streams are once again clean and can be removed from this list is the primary goal of this plan. Segments of the Robinson Run watershed covered by this plan are on the 2004 and previous 303(d) lists for AMD-related pollutants: pH, iron, and manganese.[1]. Figure 5 draws these AMD-impaired streams as thick dashed lines. These impairments are further explained in Table 3.

Figure 5: Impaired streams in the Robinson Run watershed

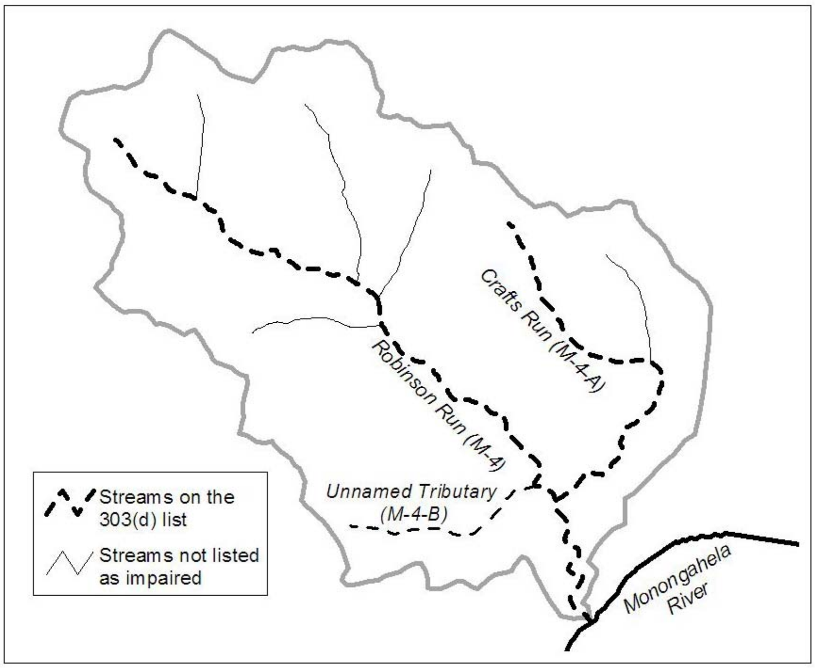


Table 3: Stream segments impaired by acid mine drainage

Stream code	Stream name	Impaired miles	Fe	Mn	pH
M-4	Robinson Run	4.4	x	x	x
M-4-A	Crafts Run	2.5	x	x	x
M-4-B	UNT #1/Robinson Run	1.2	x	x	x

Source: All impairments from 2004 303(d) list Supplemental Table B (WVDEP, 2004a). Impaired miles are not included in the 2004 or 2002 303(d) lists (WVDEP, 2004a and 2003). According to the 1998 303(d) list (WVDEP, 1998), Robinson Run is impaired for 4.4 miles, even though more recent monitoring suggests that the upper portion of Robinson Run may no longer be impaired by AMD. No 303(d) lists show impaired miles for Crafts Run or UNT #1/Robinson Run; therefore, these miles were calculated for this Watershed Based Plan.

[1] After the aluminum water quality standard was changed from total to dissolved, previous total aluminum listings have become moot. Dissolved aluminum data are now required to list streams as impaired by aluminum. The recent change in the manganese standard may also make previous manganese listings moot, depending on the location of water supply withdrawals.

3.1 Abandoned mine lands

The most important nonpoint source pollution in the Robinson Run watershed is AMD from abandoned mine lands (AMLs). A total of 31 AMLs are documented in the Robinson Run watershed and are listed in Appendix A. Problem Area Descriptions (PADs) and other documentation for these sites indicate that only eleven of these AMLs discharge AMD; these AMLs are listed in Table 4.

Other AMLs likely do not discharge AMD; therefore, they are only listed in Appendix A. The methods used to identify sites in Table 4 and Appendix A are not foolproof. If new information indicates that an AML that was left out of Table 4 does, in fact, discharge AMD, the Watershed Based Plan will be updated as appropriate.

Table 4: Abandoned mine lands in the Robinson Run watershed known to discharge acid mine drainage

Problem area number	Problem area name	Receiving stream code	Receiving stream
80	Robinson Run Drainage & Portals	M-4	Robinson Run
82	Robinson Run Landslide	M-4, M-4-B	Robinson Run/UNT#1 Robinson Run
546	Crafts Run Portals and Refuse	M-4-A	Crafts Run
1127	Rosedale Strip & Highwall	M-4-A	Crafts Run
1131	Robinson Run #1	M-4	Robinson Run
1181	Lazzelle Landslide, Tipple & Highwall	M-4	Robinson Run
1789	Robinson Run #6	M-4	Robinson Run
1977	Murphy	M-4	Robinson Run
4180	Bethel Portals	M-4	Robinson Run
4421	Concorde Corporation	M-4	Robinson Run
5938	Robinson Run (Cale) Mine Drainage	M-4	Robinson Run

Source: OSM (2005) and WVDEP (Various dates).

3.2 Permitted mines and bond forfeiture sites

The Robinson Run watershed contains a number of active surface and underground mining operations, coal preparation plants, and mine refuse disposal sites. The majority of the Pittsburgh coal seam located within the watershed boundary has been removed, but other coal seams including the Sewickley, Redstone, and Waynesburg are currently being mined. A number of mine prospect permits have also been issued in the watershed.

By law, mining operations are required to obtain mining permits and NPDES permits in order to operate mines and discharge into Robinson Run. Table 5 lists the active mining permits and the accompanying NPDES permits in the Robinson Run watershed.

Some coal mines were abandoned after the 1977 Surface Mining Control and Reclamation Act. These bond forfeiture sites are distinguished from AMLs; they do not qualify for Section 319 funding and therefore are not a focus of this plan. Bond forfeiture sites in the Robinson Run watershed are shown in Table 6.

Table 5: Permits for active mines in the Robinson Run watershed

Mining permit	NPDES permit	Type of mining operation	Company	Operation name
s011775	WV1002678	Surface	Patriot Mining Co. Inc.	None
s100394	WV1002678	Surface	Patriot Mining Co. Inc.	Bethel North Surface Mine
s103489	WV0095311	Surface	Patriot Mining Co. Inc.	None
s105786	WV1002619	Surface	Laurita Energy Co.	None
u007683	WV1007394	Underground	Dana Mining Co. Inc	Pokey No. 3
u018200	WV1002619	Underground	Dana Mining Co. Inc	No Name
u025100	WV1011715	Underground	Dana Mining Co. Inc	No Name
u105086	WV0095206	Underground	Dana Mining Co. Inc	Mine #2
o006383	WV1002619	Other	Coresco, Inc.	Refuse Disposal
o008283	WV1002619	Other	Coresco, Inc.	Preparation Plant
o100589	WV1007602	Other	Patriot Mining Co. Inc.	Preparation Plant
o101297	WV1002619	Other	Coresco, Inc.	Crafts Run Refuse Disposal
o101593	WV1002619	Other	Coresco, Inc.	Refuse Disposal Area # 3

Source: WVDEP (2005a and b). Other mines have operated in the watershed in recent years but have finished their work and no longer hold active permits. These mines are not listed in this report.

Table 6: Bond forfeiture sites in the Robinson Run watershed

Company	Mining permit	Forfeiture date
Dean Fuels, Inc.	s2483	6/11/2001
Dean Fuels, Inc.	u16082	8/7/2001
J.A.L. Coal Company	uo251	3/28/1996
Maiden Mining Company	uo532	2/9/1998
Mon River Mining Corp.	u103186	10/30/1996
Robert Webb	4077	4/1/1987

Source: WVDEP (2005e).

3.3 The Monongahela Mine Pool and the Maiden #1 mine discharge

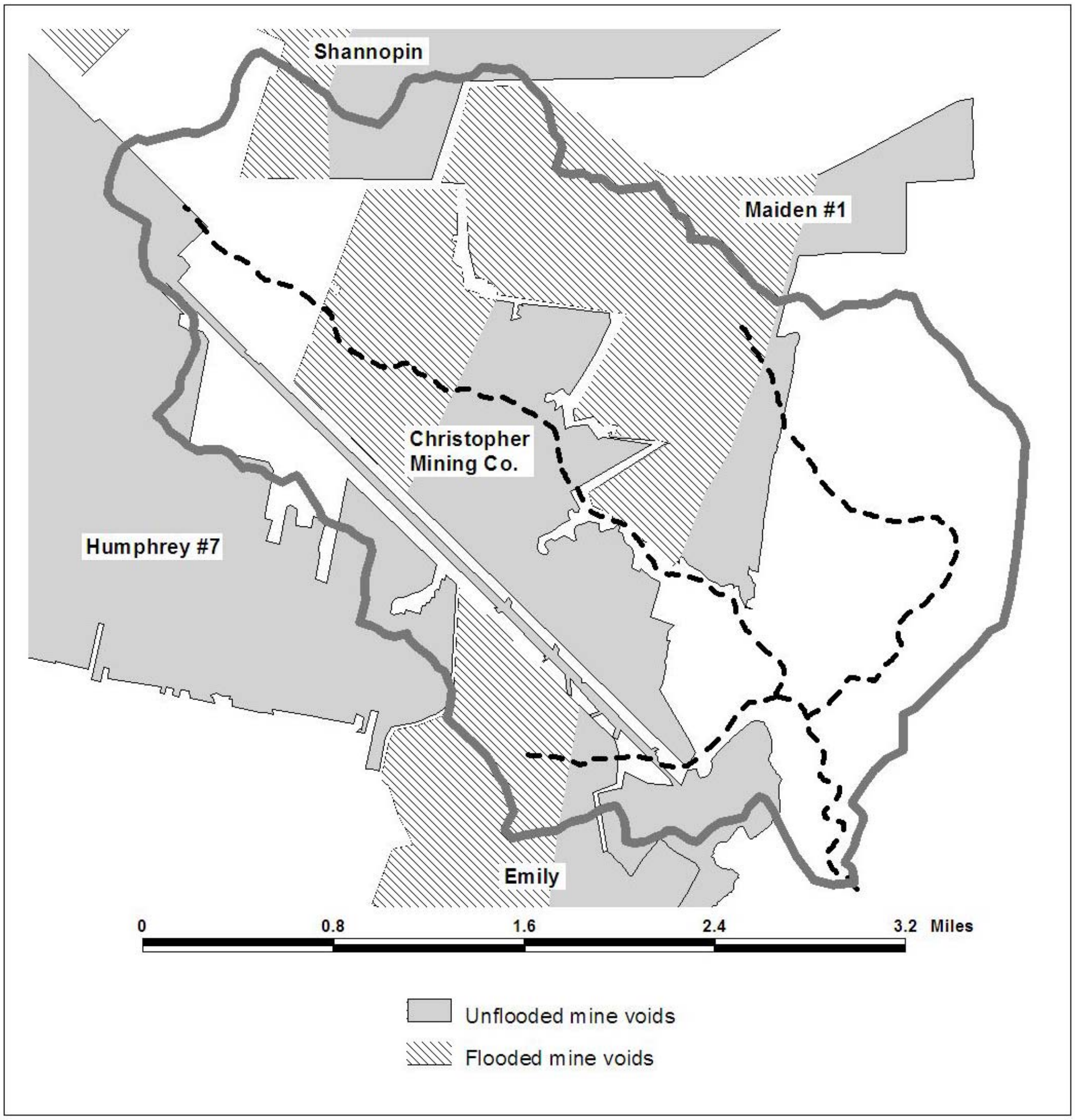
The majority of the Pittsburgh coal seam under the Robinson Run watershed has been mined, leaving massive voids. These voids extend under Robinson Run as well as large portions of the western section of the Monongahela River watershed, and these voids are flooding, creating what is known as the "Monongahela Mine Pool." While many of these mine pools are interconnected, others are isolated. The acid-producing Pittsburgh seam is known to generate significant amounts of AMD when exposed to water and oxygen. In 2003, discharges from the Monongahela Mine Pool totaled 86,400 gallons per minute, of which less than one-third was being treated (Ziemkiewicz et al., 2004).

New and innovative solutions to the nonpoint source AMD problems in the Robinson Run watershed might be linked to Monongahela Mine Pool. At least one discharge from a flooded Pittsburgh mine, the Maiden #1 discharge, is impairing Robinson Run. Although solving the mine pool problem presents massive technical and financial challenges, solutions to some AML discharges in the Robinson Run watershed might arise because of links to the mine pool.

Across the entire Monongahela Mine Pool, which extends far beyond the Robinson Run watershed boundary, many of the deep mines in the Pittsburgh seam have already flooded to a level of stability, with some mines flooded to 100% of capacity. Approximately ten mines are still flooding or are expected to flood after closing in the next few years. These ten mine pools will likely stabilize hydrologically within the next fifteen years, with many of them stabilizing within the next two to three years. While many of the mines in the Pittsburgh seam are separated by barriers, barrier leakage often occurs, allowing adjacent mines to fill up with water. The interconnections between the mines has created the largest groundwater aquifer on the east coast (Ziemkiewicz et al., 2004).

As shown in Figure 6, the main Pittsburgh mine pool in the Robinson Run watershed is located in the Maiden #1 mine. In 2003, the Maiden #1 mine was 28% flooded, with a pool elevation of 900 feet, the elevation of its discharge to Robinson Run. Because it is already discharging at the surface, it will likely never flood to full capacity, keeping approximately 72% of the mine void exposed to oxygen. This mine pool level is higher than the nearby Shannopin mine pool, which has an 800 foot elevation. A coal barrier between the Maiden #1 and Shannopin mines prevents it from draining into the rest of the Pittsburgh seam pool. Therefore, the Maiden #1 pool is an isolated pool (Ziemkiewicz et al., 2004).

Figure 6: Pittsburgh mines underlying the Robinson Run watershed and surrounding areas



Source: Mine pool shapes from Ziemkiewicz et al. (2004) and WVGES (2003).

Wet, oxygen-rich mine environments will ensure that AMD continues to be produced into the indefinite future. Unless a treatment system is installed at the discharge—or an alternative method of treatment is developed—AMD from the Maiden #1 will continue to impair Robinson Run. As shown in Table 7, data from several sources agree that the discharge from the Maiden #1 mine is large and contains high levels of AMD.

Table 7: Maiden #1 discharge water chemistry from various sources

Parameter	PAD	PAD revision	Discharge monitoring reports	Local organization	New data
Flow (gpm)	500	600	561		
pH (SU)			3.2	3.0	3.2
Total hot acidity (mg/L)			5,621		
Iron (mg/L)			925	758	641
Aluminum (mg/L)			248	122	136
Manganese (mg/L)			4.8	5.0	5.8
Specific conductance (uS/cm)				4,850	4,070

Source: PAD flow is from June 5, 1984 and PAD revision flow is from February 16, 1996 (WVDEP, Various dates). Discharge monitoring report data are averages of the 22 available months from July 2002 through June 2004 for NPDES permit WV0095206 monitoring location WL-3 (WVDEP, 2004b). Local organization data are from March 24, 2004 (UMRA, 2004). New data were collected May 31, 2005 as background for this report (Nichols, 2005).

Discharges from the Monongahela Mine Pool are becoming an ever increasing problem as mines continue to flood. Location, level of flooding, and age of the mine pools have a significant impact on the quality of the mine pool discharges. Ziemkiewicz et al. (2004) classify the Pittsburgh mines as either above-drainage (not flooded) or below-drainage (flooded). This characteristic affects many of the water quality conditions in the individual mine pools:

- pH is bimodal throughout the basin, with few exceptions, with most above-drainage mines being less than 4.5 and most below-drainage mines being above 4.5.
- Iron is by far the highest-concentration metal and is more-or-less uniformly distributed, with minor variations apparently related to discharge age.
- Manganese and aluminum are low in concentration and generally restricted to above-drainage and near-outcrop mine settings.
- Net alkalinity and pH are bimodal. Most mines that are below drainage in the basin are net alkaline, even though they carry a significant iron load (Ziemkiewicz et al., 2004).

Spatial variability of mine-water chemistry was found to be non-random and controlled by three principal factors:

- Age of mine discharge post-flooding,
- Depth of mine and degree of exposure to oxygen (e.g. below drainage versus above drainage), and
- Special variability between mine locations in factors such as overburden geology/chemistry and closed-mine management such as sludge injection or rock dust application (Ziemkiewicz et al., 2004).

The Monongahela Mine Pool is a regional problem. While remediation projects could be built at each AML through which the various mine pools discharge, there are other options. Currently, mining companies have established a series of pumps to keep various mine pools at levels low enough to prevent surface discharges and to allow access to coal reserves above the Pittsburgh seam. Much of the water in the mine pools is transported to Consolidation Coal Company’s Flaggy Meadows AMD treatment plant, located south of the Robinson Run watershed. One solution, therefore, to the Maiden #1 mine discharge and other deep mine discharges in the Robinson Run watershed might be to pump the mine pools down to prevent surface discharges, and to send the polluted water to Flaggy Meadows for treatment.

Other AMD treatment facilities also exist in the region. In particular, the Bowlby, Fetty, and Eddy facilities are even closer than Flaggy Meadows. Consideration should be given to whether an appropriate solution to the Maiden #1 and other deep mine discharges might involve one of these nearby treatment plants.

In the adjacent Dunkard Creek watershed, just north of Robinson Run in Pennsylvania, the Shannopin Mine Pool was predicted to start discharging untreated AMD to Dunkard Creek. The Pennsylvania Department of Environmental Protection worked out an arrangement with MEPCO Inc. to build a new treatment facility. MEPCO is paying the ongoing operations and maintenance costs. Pumping water from the Pittsburgh seam dewaters the Sewickley coal seam, located above, and makes it accessible for mining. With some additional treatment, water from the treatment plant will be clean enough for industrial use, and might spur local economic development and provide income to MEPCO. This kind of solution might be a model for solving similar mine pool problems in the area.

Another alternative might be a regional solution. Rather than relying on agreements with active mining companies or specific 319 projects, it might be cheaper on the scale of the entire mine pool to develop a comprehensive, integrated treatment system. Many different funding sources would have to be considered for such a system, including active mining operations, the West Virginia Special Reclamation Fund for use on bond forfeiture sites, the AML Trust Fund, Office of Surface Mining Watershed Cooperative Agreement Program grants, and additional government funding. If organized and approved, 319 funds might play an important role.

4. NONPOINT SOURCE MANAGEMENT MEASURES

The following list describes in depth the various measures that may be used to control AMD. Numbers in parentheses following the name of the method indicate the potential load reductions when the method is used correctly and in the proper situation.

4.1 Land reclamation

- **Removing acid-forming material (95%).** This method has the potential to eliminate the acid load completely if all of the acid-forming material can be removed. In the context of the Robinson Run watershed, this method is unlikely to eliminate the loads to the watershed or the subwatersheds, because acid-forming materials do not seem to be gathered in small areas, and because where such materials are on the surface, there are other sources of AMD nearby. Furthermore, the cost of removing the materials is much greater than the cost of covering them with an impervious layer and revegetating the cap.
- **Isolating acid-forming material from flowpaths (50%).** See the next two items. It is difficult to estimate the efficacy of these measures exactly. On the one hand, some AMD is often visible seeping from the edges of reclaimed areas. On the other hand, a measurement of AMD loads frequently shows such seeps are small compared to loads from nearby mine openings.
- **Sealing from above.** Infiltration of water into acid-forming material can be slowed by covering the material with low-permeability material, such as clay, and covering that layer with a vegetated layer to stabilize it. Effective reclamation and revegetation can eliminate a large proportion of the AMD from a given site.
- **Isolating from below.** Interactions between water and acid-forming materials can be further minimized by separating the waste material from impermeable bedrock below with conductive materials. Water may then flow beneath the spoil and be conducted away from it rapidly, so the water table does not rise into the spoil.
- **Surface water management.** Rock-lined ditches or grouted channels can be used to convey surface water off site before it can percolate into acid-forming material. Limestone is often used in such channels to neutralize acidity, as with oxic limestone channels (OLCs), discussed below.

4.2 Passive AMD treatment

- **Reducing and Alkalinity Producing Systems (RAPSs) (25 g acidity/m^2).** In these systems, also known as “successive alkalinity producing systems” and “vertical flow ponds,” water encounters two or more treatment cells in series. First, water passes through organic material to deplete dissolved oxygen. Several helpful reactions take place in the anoxic environment. First, bacteria reduce sulfate in an alkalinity producing reaction. Second, ferric iron, which comes into contact with pyrite, should reoxidize the sulfur and turn to ferrous iron. In a second cell, the anoxic solution comes into contact with limestone. H^+ acidity is neutralized through contact with the limestone. Additional alkalinity dissolves into the water as well. Iron does not armor the limestone because it is the ferrous form. Water then runs through an aeration and settling pond, in which ferrous iron oxidizes and then precipitates out of solution as ferric hydroxide. The acidity released in this process is neutralized by the alkalinity that has accumulated in the solution.
- **Sulfate-reducing bioreactors (40 g acidity/m^2).** These systems also consist of organic matter and limestone, but in sulfate-reducing bioreactors, the materials are all mixed in a single cell. Some of the organic material included is of a coarser nature, such as sawdust or woodchips. Reactions in these systems are similar to those in RAPSs: compost eliminates oxygen, and drives the iron and sulfur to reduced forms. The coarser organic matter may serve to protect hydraulic conductivity and may retain metals as various organic complexes.

- **Manganese removal beds (MRBs) (to 2 mg/L).** Manganese may be removed from AMD either by active treatment (Section 4.3) or by MRBs. In MRBs, water is passed over a wide limestone bed, and dissolved manganese oxidizes and precipitates from solution.
- **Oxic (or Open) limestone channels (30%).** Research to estimate the efficacy of OLCs is active. OLCs have the advantage that continually moving water may erode any armoring from limestone, and that water flow should remove precipitates from OLCs so that they do not interfere with acid neutralization. In practice, the efficacy of OLCs may suffer because they are too short, most limestone may be placed so as to react with water only at high flows, and fluctuating water levels enhance armoring. Recent research suggests that the acid neutralization that takes place in OLCs is actually greater than can be accounted for by limestone dissolution
- **Limestone leachbeds (50%).** Limestone leachbeds are most effective when water has a pH of 3 or less, and when water retention times are short (~90 minutes). The low pH promotes rapid limestone dissolution, but the short retention time prevents armoring.
- **Steel slag leachbeds (addition of alkalinity).** Steel slag leachbeds are not exposed to AMD. Rather, circumneutral feed water passes through these leachbeds, and that water is then mixed with AMD to reduce its acidity drastically.
- **Compost wetlands (wide range).** Constructed wetlands can serve multiple functions in AMD treatment. Wide areas of exposure to the atmosphere allow metals in solution to oxidize. Slower waters allow precipitates to fall out of suspension. Anaerobic zones in sediments allow for sulfate reduction, which consumes acidity. Inclusion of limestone in the substrate provides an additional alkalinity source and helps maintain conditions that support sulfate reduction.
- **Grouting (50%).** Setting up grout walls or curtains in deep mines has great potential to solve AMD problems. Ideally, such barriers may serve to keep water from entering mines and interacting with acid-forming materials. They must be constructed carefully so as not to build water pressures near a weak point and to avoid blowouts. Also, fractures in bedrock always allow some water into mines, even if flows are eliminated. A grouting project at Winding Ridge, near Friendsville, MD, decreased acidity by 50% (MPPRP, 2000).

4.3 Active AMD treatment

- **Treating (100+%).** A variety of active treatment methods exist for AMD. One of a number of alkaline chemicals can be mixed with the polluted water. The mixture may then be aerated and is finally passed through ponds allowing metal hydroxides to settle out as sludge.

5. LOAD REDUCTIONS AND COSTS

The TMDL for the Monongahela watershed in West Virginia, which includes the Robinson Run watershed, set goals for pollutant reductions from nonpoint and point source activities that, if enacted, should improve water quality so that the stream segments meet standards and are removed from the 303(d) list (USEPA, 2002). While the TMDL calls for wasteload allocations for specific point sources, load allocations for nonpoint sources are not tied to specific AMLs. Instead, the load allocations are provided catchment-by-catchment. If all wasteload and load allocations for aluminum, iron, manganese are met, the TMDL asserts that the water quality criteria for pH will also be met (USEPA, 2002).

As noted in Chapter 2, the aluminum and manganese criteria have become more lenient since the TMDL was approved. The aluminum and manganese TMDL targets therefore may be more stringent than required to meet current water quality standards, and the costs calculated in this chapter may be overestimates. In particular, for streams that no longer have a manganese criterion, the costs of MRBs may be entirely avoided. Because the TMDL has not been updated to account for these water quality standard changes, this Watershed Based Plan calculates load reductions and costs based on the standards in place when the TMDL was approved.

Table 8 lists the load allocations from the TMDL in the “TMDL target” column. Implementation of this Watershed Based Plan should reduce loads to those goals. Current loads for each site are also shown in Table 8; calculations are described in Appendix B. The treatment measures proposed for each site are sized with the goal of reducing the loads to meet the TMDL targets. If measures are implemented and targets are still not met, it may be necessary to collect more data and to design additional treatment measures.

Table 8: Reductions required to meet TMDL targets for abandoned mine lands

Stream name	Stream code	Pollutant	Current load (lb/yr)	TMDL target (lb/yr)	Reduction required (%)
Robinson Run	M-4	Al	610,000	82	99.99%
		Fe	2,270,000	1,193	99.95%
		Mn	11,800	780	93.4%
Crafts Run	M-4-A	Al	327,000	16	99.99%
		Fe	1,220,000	656	99.95%
		Mn	6,300	47	99.3%
UNT #1/ R. Run	M-4-B	Al	2,200	30	98.6%
		Fe	8,100	356	95.6%
		Mn	42	185	None required

Note: Detailed load calculations are shown in Appendix B. TMDL targets are load allocations for each pollutant in each subwatershed from USEPA (2002), and are rounded for this plan.

Treatment systems for each site are chosen based on the assumption that Section 319 funds will continue to be limited to funding capital costs. Treatment options are therefore limited to land reclamation and passive systems that do not require ongoing operations and maintenance. Load reductions and costs are based on what can reasonably be achieved by land reclamation or installing appropriate passive treatment systems.

AMD may be generated within accumulations of mine spoil or refuse on the surface, or in similar acid forming materials located in underground mines. If site descriptions suggest that materials on the surface are responsible for the AMD, then the remediation cost is determined according to the acres of land requiring reclamation. In some cases, spoil piles may be large and adequately vegetated, and passive water treatment may be more cost effective.

When AMD flows out of underground mines, a passive treatment system can be chosen and sized based on water chemistry and flow data. The appropriate passive water treatment system for the sources that have been studied in the North Fork and nearby watersheds is a RAPS, according to Watzlaf et al. (2004). Net acidity in the water rules out treatment with only aerobic wetlands. Concentrations greater than 1 mg/L of dissolved oxygen, aluminum, or iron in the ferric state rule out use of anoxic limestone drains (ALDs). It is also assumed that deep mine AMD sources that have not been carefully examined will also produce water requiring RAPSs. RAPSs are sized according to the acidity load from the AMD source. Detailed sizing and cost assumptions are included in Appendix C.

Because RAPSs are not designed to treat manganese, MRBs are also included in the cost estimates. MRBs are sized to achieve a 24-hour retention time, which has proven effective for manganese removal. Detailed sizing and cost assumptions for MRBs are also included in Appendix C.

The Office of Surface Mining, Reclamation and Enforcement's (OSM's) AMDTreat computer program is used to calculate costs for both RAPSs and MRBs. Table 9 summarizes the cost calculations performed in this Watershed Based Plan: To meet TMDL targets for 8.1 miles of impaired streams, it will cost more than $2.14 million. This cost is likely an underestimate because of the lack of data at many sites. The following sections describe each AML known to discharge AMD, and where possible projects the cost to install appropriate treatment at each site.

Table 9: Summary of costs and stream miles improved

Stream code	Subwatershed	Impaired miles	Estimated future cost for water remediation
M-4	Robinson Run	4.4	> $1,000,000
M-4-A	Crafts Run	2.5	> $1,000,000
M-4-B	UNT #1/Robinson Run	1.2	$140,000
	Total	8.1	>$2,140,000

Source: Impaired miles from Table 3. Estimated future costs for water remediation are calculated in this Watershed Based Plan, as detailed below.

5.1.1 Upper Robinson Run

This portion of the watershed consists of subwatersheds 72 and 169 in the TMDL.[2] Disturbed areas, AMLs, and mining permits all indicate that this subwatershed has been mined extensively. Recent water quality data, however, suggest that no reductions are needed here. Although the TMDL requires reductions from subwatershed 72, recent water quality monitoring below these two watersheds show no violations of AMD-related water quality criteria (UMRA, 2004). Recent instream water quality measurements also show compliance with criteria (WVDEP, 2004b).

Nevertheless, the PAD for the single AML within this subwatershed indicates some AMD. A monitoring program in the Robinson Run watershed should include measurements that confirm that this site and other AMLs in the area are benign. Since no work seems to be required, no costs are estimated.

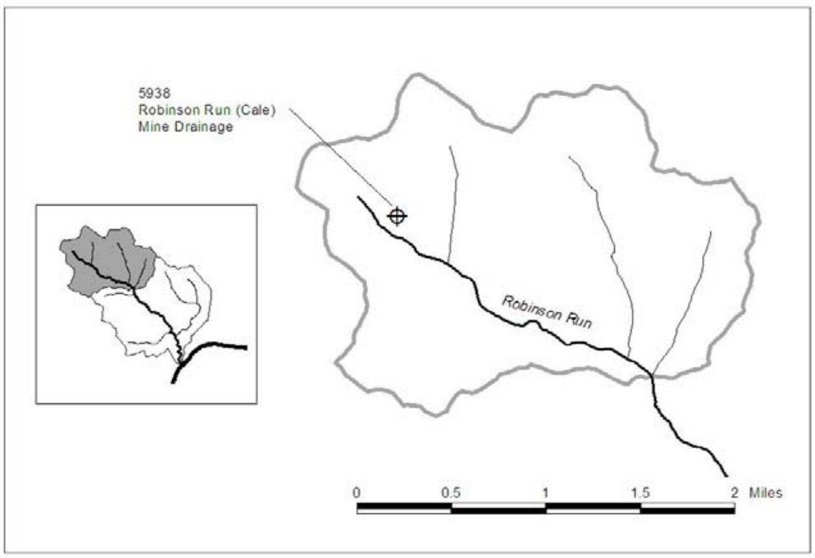
[2] The TMDL document (USEPA, 2002) draws the boundary between these two subwatersheds incorrectly, so they are most easily combined.

Table 10: Costs and descriptions of abandoned mine lands in the Upper Robinson Run subwatershed

Site name (Problem area no.)	Past recla-mation cost	Site and cost description	Estimated future cost for water remediation
Robinson Run (Cale) Mine Drainage (5938)	None	Seeps at two residences have iron concentrations > 10 mg/L, but pH values of 5.5. No flow rates are given, but PAD refers to saturated areas in the lawn, rather than to flows. AMLIS identifies a clogged stream.	No estimate possible
		Total, Upper Robinson Run	No estimate possible

Source: Past reclamation costs from OSM (2005). Site and cost descriptions from OSM (2005) and WVDEP (Various dates). Estimated future costs for water remediation calculated in this plan.

Figure 7: Abandoned mine lands in the Upper Robinson Run subwatershed



5.1.2 Lower Robinson Run

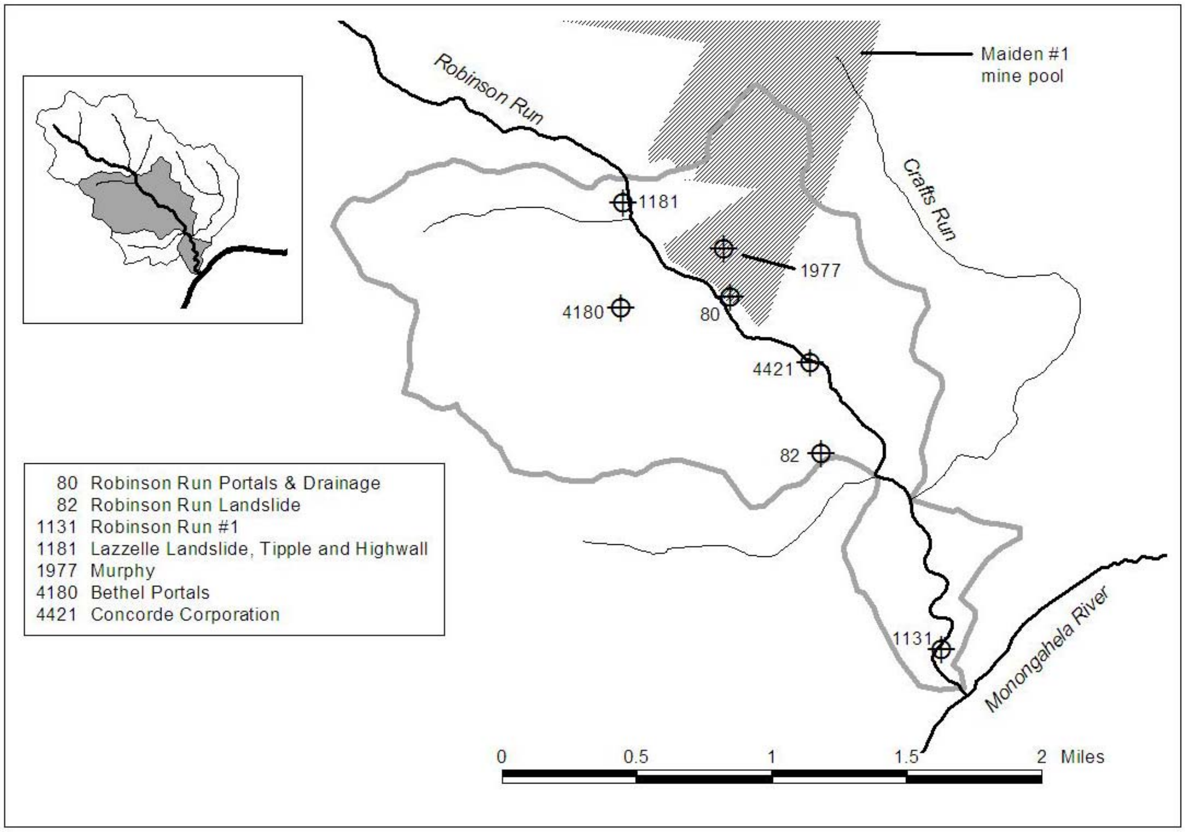
This portion of the watershed includes subwatersheds 47, 48, and 179, and the majority of the AMD loads that flow directly to Robinson Run. The largest AMD load flows from the Maiden #1 discharge, associated with Robinson Run Drainage and Portals (80). Estimates of loads and from these sites, which are mapped in Figure 8, are given in Table 11.

Table 11: Costs and descriptions of abandoned mine lands in the Lower Robinson Run subwatershed

Site name (Problem area no.)	Past recla-mation cost	Site and cost description	Estimated future cost for water remediation
Robinson Run Drainage & Portals (80)	None	Three portals discharging AMD. The largest is the Maiden #1 discharge. Load estimates in lbs/year: Al: 610,000, Fe: 2,270,000, Mn: 11,800, and acidity: 13,800,000.	>$1,000,000
Robinson Run Landslide (82)	$351,032	Large reclaimed site on subwatershed divide between Robinson Run and unnamed tributary. No flow or water quality data available before or after reclamation.	No estimate possible
Robinson Run #1 (1131)	None	Site contains ten acres of refuse and AMD flowing at 10 gpm. No water quality data available.	No estimate possible
Lazzelle Landslide, Tipple and Highwall (1181)	$96,800	Reclaimed site includes sealed portal. No flow or water quality data available before or after reclamation.	No estimate possible
Murphy (1977)	None	A pond on this site must be eliminated. Although this site is above the mine pool, it does not seem to discharge water from it. No flow or water quality data available.	No estimate possible
Bethel Portals (4180)	None	Site has subsidence holes and a discharging portal. No flow or water quality data available.	No estimate possible
Concorde Corporation (4421)	$631,271	Large reclamation project with unsuccessful attempt at AMD treatment. No flow or water quality data available.	No estimate possible
		Total, Lower Robinson Run	>$1,000,000

Source: Past reclamation costs from OSM (2005). Site and cost descriptions from OSM (2005) and WVDEP (Various dates). Estimated future costs for water remediation calculated in this plan.

Figure 8: Abandoned mine lands in the Lower Robinson Run subwatershed



Notes: Maiden #1 mine pool shape from Ziemkiewicz et al. (2004) and WVGES (2003). This pool extends beyond the boundary of this map.

5.1.3 Crafts Run

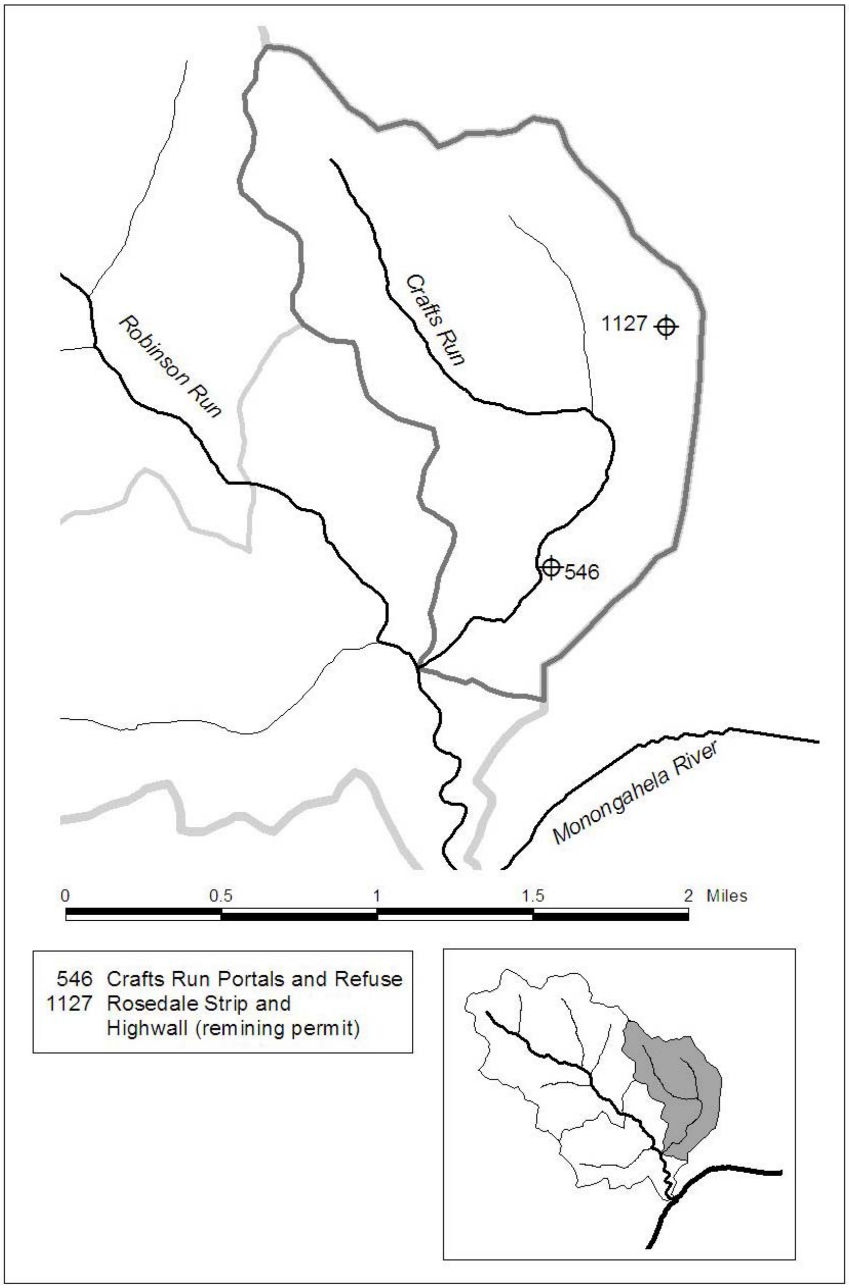
The Crafts Run subwatershed has two AMLs discharging AMD, as shown in Table 12 and Figure 9. Only one has a flow that has been measured. The other is currently part of a remining permit. The remining process is expected to reduce AMD loads from this site.

Table 12: Costs and descriptions of abandoned mine lands in the Crafts Run subwatershed

Site name (Problem area no.)	Past recla-mation cost	Site and cost description	Estimated future cost for water remediation
Crafts Run (546)	$399,053	This area has been reclaimed, but the project included no measures to improve AMD discharging from portals. Load estimates in lbs/year: Al: 327,000, Fe: 1,220,000, Mn: 6,300, and acidity: 7,400,000.	>$1,000,000
Rosedale Strip and Highwall (1127)	None	This site includes sites that must be reclaimed and 3 gpm of AMD. The future cost for water remediation will be depend on the success of a current remining project.	No estimate possible
		Total, Crafts Run	>$1,000,000

Source: Past reclamation costs from OSM (2005). Site and cost descriptions from OSM (2005) and WVDEP (Various dates). Estimated future costs for water remediation calculated in this plan.

Figure 9: Abandoned mine lands in the Crafts Run subwatershed



5.1.4 Unnamed tributary to Robinson Run

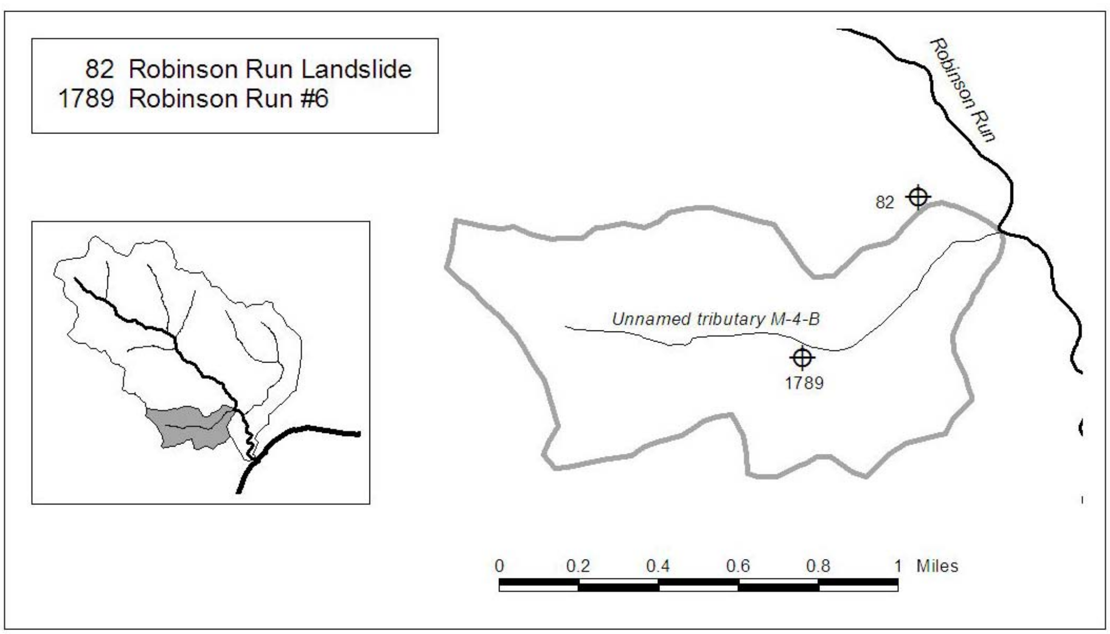
Although loads of aluminum, iron, and manganese from AMLs in this subwatershed must be reduced drastically in order to meet the TMDLs allocations, PADs indicate that only two AMLs are polluting this tributary. Robinson Run Landslide (82) extends across the boundary between this subwatershed and that of the mainstem of Robinson Run. It is therefore also listed with this subwatershed, although there is no information to calculate its load.

Table 13: Costs and descriptions of abandoned mine lands in the unnamed tributary subwatershed

Site name (Problem area no.)	Past recla-mation cost	Site and cost description	Estimated future cost for water remediation
Robinson Run Landslide (82)	$351,032	Large reclaimed site on subwatershed divide between Robinson Run and unnamed tributary. No flow or water quality data available before or after reclamation.	No estimate possible
Robinson Run #6 (1789)	Probably reclaimed as part of Robinson Run Landslide (82)	This site was probably reclaimed. A description before reclamation found AMD. Load estimates in lbs/year: Al: 2,200, Fe: 8,100, Mn: 40, and acidity: 49,000.	$140,000
		Total, Unnamed tributary	$140,000

Source: Past reclamation costs from OSM (2005). Site and cost descriptions from OSM (2005) and WVDEP (Various dates). Estimated future costs for water remediation calculated in this plan.

Figure 10: Abandoned mine lands in the unnamed tributary subwatershed



6. TECHNICAL AND FINANCIAL ASSISTANCE

A combination of federal and state agencies, academic institutions, watershed organizations, consultants, and citizens will be involved in providing technical and financial assistance for Robinson Run watershed projects.

6.1 Technical Assistance Providers

Technical assistance is needed for the following tasks:

- coordinating and applying for the various funding sources;
- collecting data at AMD sources in preparation for the design of remediation projects;
- creating conceptual designs of remediation projects;
- creating detailed engineering designs of remediation projects;
- performing project management, including putting projects out for bid, managing projects, and tracking their progress; and
- monitoring instream and source water quality following the installation of remediation projects to document their effectiveness.

6.1.1 West Virginia Department of Environmental Protection

Two WVDEP divisions will provide technical assistance. The Division of Water and Waste Management monitors the water quality of the watershed through its Watershed Assessment Program and its pre-TMDL monitoring program (WVDEP, 2005f). This division also provides technical assistance for the use of best management practices, educates the public and land users on nonpoint source issues, enforces water quality laws that affect nonpoint sources, and restores impaired watersheds through its Non-Point Source Program (WVDEP, 2005g).

WVDEP's OAMLR directs technical resources to watersheds to address AMLs. Through their Stream Restoration Group (SRG), the office conducts extensive source monitoring of AMLs—as well as instream monitoring—before remediation systems are designed.

6.1.2 Office of Surface Mining, Reclamation and Enforcement

OSM provides technical assistance by sharing their knowledge and experience in designing and financing AML remediation projects.

6.1.3 West Virginia University

A number of the colleges and individuals at the university may provide assistance for projects in the watershed. The National Mine Land Reclamation Center (NMLRC), housed at West Virginia University has experience providing conceptual site designs for reclamation projects and monitoring water quality produced by AMLs before and after projects are installed. NMLRC is dedicated to developing innovative AMD treatment technologies. Technical assistance may also be provided by departments within the university with expertise in fisheries and wildlife resources, mine land reclamation, and water quality improvement.

6.1.4 Other technical assistance providers

Other agencies and organizations may also provide technical assistance. Natural Resources Conservation Service (NRCS) engineers have designed AMD remediation projects in some West Virginia watersheds and may be available for assistance. Local conservation districts may also be a repository of information and assistance. In addition, USEPA staff with expertise in AMD from Region 3 and from headquarters may provide technical assistance.

6.2 Funding Sources

Several funding sources are available for nonpoint source AMD remediation on AMLs and for water quality monitoring, including:

- Section 319 funds,
- the Abandoned Mine Land Trust Fund,
- the 10% AMD Set-Aside Fund,
- Watershed Cooperative Agreement Program grants,
- Stream Partners Program grants,
- Brownfields grants,
- other government funding sources, and
- private foundation grants.

These funding sources are described in turn below.

6.2.1 Section 319 funds

Clean Water Act Section 319 funds may be provided by USEPA to WVDEP to be used for reclamation of nonpoint source AMD sources. This Watershed Based Plan is being developed so that these funds can be allocated to the Robinson Run watershed. WVDEP's Division of Water Resources Non-Point Source Program sets priorities and administers the state Section 319 program (WVDEP, 2005g).

6.2.2 The Abandoned Mine Land Trust Fund

Before 1977, when the Surface Mining Control and Reclamation Act was enacted, coal mines generally did not manage acid-producing material to prevent AMD or treat the AMD that was produced. These "pre-law" mines continue to be significant AMD sources and are treated as nonpoint sources under the Clean Water Act.

To reclaim these AMLs, the Act established the AML Trust Fund. This fund, supported by a per-ton tax on mined coal, has been allocated to coal mining states for remediation projects, according to a formula that takes states' current coal production into account. Authorization for this tax expired on September 30, 2004, and if a permanent reauthorization is not secured, this very important source of funding for AMD remediation may be lost.[3]

For many reasons, the AML Trust Fund has failed to address AMD at a rapid pace:

- The priorities for disbursed monies place health and safety hazards ahead of water quality issues.
- Even though OSM allows states to assign water quality problems a priority equal to that of potential health and safety problems, WVDEP has been slow to change its priorities accordingly.
- Only part of the AML Trust Fund's income is disbursed each year, so that less money is available for remediation than the legislation initially envisioned.
- Some of the money that is disbursed from interest generated by the fund pays for health benefits for former miners.

[3] Reauthorization of the AML Trust Fund, which expired on September 30, 2004, is still not settled. At the time that this document is being written, the fund has been temporarily reauthorized through June 2006. A new OSM rule published in September 2004 also reauthorizes a much smaller per-ton tax. It is still not clear what shape a final reauthorization might take.

- At least half of the AML fees collected in each state are allocated back to the state of origin, and are not available for AML reclamation in other states; therefore, much of the AML monies are earmarked for states with few AML problems.
- Some of the money allocated to West Virginia from the AML Trust Fund is used for water-line extensions, because deep mines are responsible for the failure of a number of private wells.
- Funds that are sent back to West Virginia are spent on agency staff salaries in addition to on-the-ground remediation.

Still, WVDEP has funded many AMD remediation projects on AMLs. But these projects are typically not designed to meet stringent water quality goals like those set out in this Watershed Based Plan. The agency typically uses a small number of cost-effective techniques, such as open limestone channels, and chooses the layout for these measures based on how much land is available (for example, the distance between a mine portal and the boundary of properties for which the agency has right-of-entry agreements).

Unless significantly more money were allocated to West Virginia's AML program and these augmented funds were spent on water quality problems, the AML Trust Fund will not be sufficient to implement the AML pollutant reductions needed to meet the goals of this Watershed Based Plan in the foreseeable future. And if the fund is not reauthorized, this important source of funding may disappear completely. OAMLR administers West Virginia's use of AML Trust Fund grants.

6.2.3 10% AMD Set-Aside Fund

The 10% AMD Set-Aside Program allows states to reserve up to 10% of their annual AML Trust Fund allocations as an endowment for use on water quality projects. These funds are critically important, because while regular AML Trust Fund allocations can only be spent on capital costs, 10% AMD Set-Aside Fund allocations can be spent on operations and maintenance.

As of March 14, 2005, $14.7 million remains in the West Virginia Set-Aside Fund (Darnell, 2005). The agency typically only spends the interest; therefore, the amount available for AMD projects varies with interest rates. In fiscal year 2001 the fund had the highest amount of interest available: $760 thousand. As of fiscal year 2003 the interest available has fallen to $211 thousand, and in subsequent years interest has fallen even further (Darnell, 2005). Long term commitments have been made to fund many AML projects across the state.

These funds cannot be allocated to a watershed until after a Hydrologic Unit Plan is developed and approved by OSM.

6.2.4 Watershed Cooperative Agreement Program

Grants specifically for AMD remediation projects on AMLs are available through OSM's Watershed Cooperative Agreement Program (WCAP). The WCAP is part of the Appalachian Clean Streams Initiative. Grants of up to $100,000 are awarded to not-for-profit organizations that have developed cooperative agreements with other entities to reclaim AML sites (OSM, 2004). A match is required to receive these grants and is typically met with Section 319 funds.

6.2.5 Stream Partners Program

This program offers grants of up to $5,000 to watershed organizations in West Virginia. Grants can be used for range of projects including small watershed assessments, water quality monitoring, public education, stream restoration, and organizational development. These grants are available to qualifying organizations that might focus on implementing this plan.

6.2.6 Brownfields grants

Targeted Brownfields site assessments can be used to help fill in data gaps by collecting additional water quality monitoring data. In addition, Brownfields grants of up to $200 thousand are available through a competitive process; these grants can be applied to mine scarred lands. Competitive site assessment grants can be used for inventory, planning, quantification of environmental risks, and development of risk management or remedial action plans. Competitive remediation grants can then be used to build treatment systems.

6.2.7 Other government funding sources

NRCS is funding AMD remediation in the Deckers Creek watershed in north-central West Virginia though a Public Law-566 watershed restoration project. The U.S. Army Corps of Engineers has funded an AMD study and is planning to fund AMD remediation work in the lower Cheat watershed. Pending successful outcomes of these projects, these federal agencies might be potential funders for AMD remediation in the Robinson Run watershed.

6.2.8 Private foundation grants

Private foundations sometimes support qualifying organizations that are engaged in watershed restoration efforts. Nonpoint source AMD remediation projects might qualify for such funding.

7. IMPLEMENTATION SCHEDULE, MILESTONES AND MEASURABLE GOALS

Significant AMD pollutant reductions are still needed in the Robinson Run watershed. Because of the uncertainty of securing the required funds from a variety of agencies in a short period of time, the schedule, milestones, and measurable goals are divided into five-year phases and no final end date is projected for implementing all of the reductions in this Watershed Based Plan.

Many details are provided for Phase 1, which lasts from 2005 through 2009. Far fewer details are given for Phase 2, because of the difficulty of predicting how many remediation projects will be funded.

7.1 Partners to help implement this plan

As described in Section 6, many financial and technical partners might play a role in helping to implement this Watershed Based Plan. But compared with many other AMD-impacted watersheds in West Virginia, Robinson Run is at a disadvantage because no watershed organization is focused on cleaning it up. The Region VI Planning and Development Council, for which this Watershed Based Plan is developed, has an interest in cleaning up impaired streams in its service area, but this has not been a focus of the organization’s efforts.

The Upper Monongahela River Association (UMRA) has a strong interest in promoting increased recreation along the Monongahela River both up- and downstream from Robinson Run. But UMRA’s efforts have focused on developing a river trail, increasing lock hours, and developing marinas. UMRA sees improved water quality as crucial for the Monongahela River to reach its full potential as a recreational asset to the community, but this small volunteer-only group is unable to devote the significant resources that would be necessary to coordinate a clean-up of the Robinson Run watershed. UMRA, however, can take small steps to help facilitate the clean-up as resources permit.

Without an active organization facilitating the process in the watershed, the burden of implementing this Watershed Based Plan falls more directly on government agencies. In particular, WVDEP would have to play a key role. The West Virginia Division of Natural Resources might also have an important role to play. Perhaps the West Virginia Development Office might see the benefits of implementing this plan to help open up some prime locations to development that are close to Morgantown but currently polluted. Private industry, especially those companies that are still mining in the watershed and in nearby areas, might play an important role as well. Other agencies and researchers with an interest in solving the Monongahela Mine Pool problem might also be important players.

While many partners have an interest in restoring this watershed to health, momentum would likely only be generated if a new watershed organization were created to take the lead. With such a small land area and population, it is unlikely that an organization focused on Robinson Run would be successful. Perhaps more likely to generate success would be an organization that focuses on water quality in the entire Upper Monongahela River watershed in West Virginia. This organization could focus on tributaries not already in the geographical areas of existing organizations such as Friends of Deckers Creek and Friends of the Cheat. A first project could be the implementation of the Robinson Run Watershed Based Plan. Although the successful creation of a new organization cannot be guaranteed, the tasks below assign tasks to such an organization.

7.2 Phase 1: 2005 through 2009

In Phase 1, WVDEP, a new watershed organization, and others will initiate a process to generate consensus on how to systematically build remediation projects in the watershed. The broad goals for AMD remediation in Phase 1 are to continue collecting data, planning and coordinating activities among agencies and organizations, securing funding for remediation projects, constructing new projects, and maintaining existing projects.

7.2.1 Collect data

- **Monitor streams for AMD pollutants.** New monitoring data will be collected over time to help guide the process in the future and to gage progress toward meeting the goals of this plan.
- **Monitor reclaimed AML sites.** Monitoring at reclaimed sites will be used to develop operations and maintenance plans and to characterize additional treatment needs at sites that were not adequately addressed during past reclamation.
- **Monitor unreclaimed AML sites.** Monitoring will also occur at sites that have not been reclaimed, as described in the following chapter. Data will be used to design appropriate treatment systems.

7.2.2 Plan and coordinate activities

- **Establish a new Upper Monongahela River watershed organization with an initial focus on the Robinson Run watershed.** This watershed organization would play a key role in coordinating the activities of WVDEP and partners, and would also qualify for OSM WCAP funding to help pay for AMD remediation in the watershed. Provided that sufficient local interest is found, a new organization will be created.
- **Clarify the status of the Maiden Mine #1 discharge.** This plan treats the largest AMD source in the watershed, the Maiden Mine #1 discharge, as a component of the Robinson Run Drainage and Portals (80) AML site. However, there is some disagreement at WVDEP regarding whether this discharge is truly an AML. The status of this discharge must be clarified before proper funding sources can be lined up for remediation. If necessary and appropriate, this source will be added to the AML inventory so that it can be addressed using AML funding sources including Section 319 funds.
- **Develop a Hydrologic Unit Plan.** A Hydrologic Unit Plan is required for one reason: so that the 10% Set-Aside Fund can be used to pay for operations and maintenance of sites in the Robinson Run watershed.
- **Develop plans for new and improved reclamation projects.** Partners will agree on plans to install new and to improve existing reclamation projects in the watershed.
- **Develop operations and maintenance plans.** Once the Hydrologic Unit Plan is completed, partners will develop operations and maintenance plans for AML sites where reclamation has succeeded. These plans will be coordinated with OAMLR’s plans for using the 10% Set-Aside Fund.
- **Coordinate Robinson Run reclamation projects with broader solutions to the Monongahela Mine Pool.** As solutions to the Monongahela Mine Pool problem are proposed and agreed upon, partners will ensure that reclamation projects planned for the Robinson Run watershed are coordinated with broader mine pool solutions.
- **Reassess the big picture.** At the end of this five-year period, partners will reassess the strategic priorities for AMD remediation in the watershed. This assessment will be used to track improvements over time and to help plan remediation and operations and maintenance priorities for the next five-year period.

7.2.3 Secure funding

- **Secure funds for reclamation projects.** Each year, partners will secure funds to pay capital costs from the 319 program, the AML Trust Fund, and the OSM WCAP.
- **Secure funds for operations and maintenance.** Partners will also ensure that sufficient operations and maintenance funds are spent from the 10% Set-Aside Fund and other potential sources to keep all projects in the watershed functioning properly.
- **Investigate other funding sources.** NRCS Public Law 566 will also be investigated for its usefulness in funding AML reclamation in the watershed. If feasible, WVDEP and partners will work with NRCS to obtain funds. USACE funds will also be investigated.

7.2.4 Install remediation projects

- **Build new projects.** As funds are secured, new projects will be built.
- **Add water quality improvements to existing projects.** In many cases, OAMLR designs and builds remediation projects with AML Trust Fund grants that do not wholly address AMD. Wherever possible, WVDEP and partners will find additional funds such as OSM WCAPs to add on to these remediation projects so that they directly address water quality.
- **Operate and maintain existing sites.** After 10% Set-Aside funds are obtained, operations and maintenance will be performed on sites where necessary.

7.2.5 Measurable goals for Phase 1

By the end of Phase 1 in December 2009, the following measurable goals will be achieved:

- A new watershed organization will have been established. This organization will have helped facilitate remediation projects and will have been awarded at least one OSM WCAP grant.
- AMD remediation projects will have been installed on one-half of the AMLs in the Robinson Run watershed other than the Maiden Mine #1 discharge. These projects will be functioning well enough so that water discharged from these sites meet technology-based effluent limitations for pH, iron, and manganese.
- Instream water chemistry measurements will show that Robinson Run is moving toward meeting water quality standards for pH, iron, manganese, and aluminum upstream from the Maiden Mine #1 discharge. Measurements in tributaries to the Robinson Run will also show that they are moving toward meeting standards. These measurable goals will be considered met when instream monitoring shows average concentrations that are within 150% of water quality criteria.

7.3 Phase 2: 2010 through 2014

Phase 2 is described in less detail than Phase 1, because of the uncertainty in what will be finished by 2009. Partners will undertake the same four categories of activities in Phase 2:

- Collect more data in receiving streams and on AML sites;
- Develop plans for new and improved reclamation projects and for operations and maintenance;
- Secure capital funds for new and improved reclamation projects, and ensure that sufficient operations and maintenance funds are available to meet the needs of the watershed;
- Build new and improved projects and operate and maintain existing sites.

7.3.1 Measurable goals for Phase 2

Measurable goals will be determined at the start of Phase 2, and will be developed around the achievements of Phase 1. It is anticipated that remediation of all remaining AMLs will be completed in Phase 2 and that water quality standards will be met at all locations in the watershed.

8. MONITORING

Instream monitoring is important to gage the recovery of streams after remediation projects are installed, and is also crucial as partners engage in periodic planning of their reclamation priorities. Monitoring of AMD sources is also necessary to understand which sources are discharging how much pollution. These data are used to help decide on priorities, and are essential for the design of realistic treatment systems.

8.1 Instream monitoring

At least two agencies and organizations are now monitoring the Robinson Run watershed, and will continue to do so in the future.

8.1.1 WVDEP Watershed Assessment Program

According to WVDEP's five-year watershed management framework cycle, the agency performs in-depth monitoring of the state's watersheds every five years. The next monitoring year for the Robinson Run watershed is scheduled to begin in 2009. These monitoring data will be helpful to show whether Robinson Run and its tributaries are improving or declining in quality. In addition to water chemistry, technicians collect benthic macroinvertebrates to determine biological impairments and fecal coliform data to determine bacteria impairments. Technicians also perform sediment-related assessments. WVDEP will then use these data, plus data collected by other agencies and organizations, to make impairment decisions for the next 303(d) list.

8.1.2 Upper Monongahela River Association

UMRA has facilitated the collection of instream water chemistry data in 2004 and 2005, and will seek support to continue collecting these data if partners decide that such additional data is important.

8.2 Source monitoring

8.2.1 WVDEP Stream Restoration Group

SRG, which works within OAMLR, collects source data when WVDEP is designing a remediation project. Although SRG has not collected data in the Robinson Run watershed in the past, future data collection to help design appropriate treatment systems would be helpful.

8.2.2 National Mine Land Reclamation Center at West Virginia University

In some situations, NMLRC has collected source data in anticipation of creating conceptual designs for treatment systems. When appropriate, it is anticipated that NMLRC will continue to play this valuable role.

8.2.3 Upper Monongahela River Association

UMRA collected a limited amount of source data in 2004 and 2005, and will seek support to help collect source data in the future if partners decide that such additional data is important.

9. OUTREACH AND EDUCATION

Because there is no existing watershed organization in the Robinson Run watershed, outreach and education activities will be somewhat limited. If and when a new organization is established, these activities will ramp up.

9.1 Region VI Planning and Development Council

The Region VI Planning and Development Council will organize and facilitate a public meeting in late 2005 to generate community support to implement the Robinson Run Watershed Based Plan. One potential outcome of this meeting will be an agreement and a set of volunteers to begin creating a new Upper Monongahela River watershed organization with an initial focus on Robinson Run.

9.2 A new watershed organization

If and when a new watershed organization is established, it can help provide outreach and education. In particular, it is anticipated that the organization can:

- Publish a newsletter,
- Provide youth education,
- Maintain a web site,
- Organize public outreach meetings, and
- Submit press released and articles to local newspapers.

9.3 West Virginia Department of Environmental Protection

Prior to collecting new monitoring data in 2009, WVDEP will hold a public meeting to gather suggestions for monitoring locations. WVDEP will present information at this meeting on the status of plans for remediating nonpoint source pollution in the watershed.

9.4 Upper Monongahela River Association

UMRA maintains a Web site, www.uppermon.org, and will include relevant information regarding the clean-up of the Robinson Run watershed on this site.

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APPENDIX A. ALL ABANDONED MINE LANDS IN THE ROBINSON RUN WATERSHED

Many AMLs do not discharge polluted water. Table 4 in Section 3 lists those AMLs known to discharge AMD. Table 14 lists the sites in Table 4 plus all other sites that have been inventoried by WVDEP. Although the PADs and other information available at OAMLR office suggest that many of these sites do not discharge AMD, they are included in this plan in case new data show otherwise. Some of these AML sites have been combined during reclamation.

Table 14: All abandoned mine lands in the Robinson Run watershed

Problem area no.	Problem area name	Receiving stream Code	Receiving stream Name
78	Robinson Run Tipple #3	M-4	Robinson Run
80	Robinson Run Drainage & Portals	M-4	Robinson Run
81	Robinson Run Tipple #1	M-4	Robinson Run
82	Robinson Run Landslide	M-4/M-4-B	Robinson Run/UNT#1 Robinson Run
546	Crafts Run Portals and Refuse	M-4-A	Crafts Run
1127	Rosedale Strip & Highwall	M-4-A	Crafts Run
1129	Robinson Run #3 & #4	M-4-B	UNT #1 Robinson Run
1130	Robinson Run #2	M-4/M-4-A	Robinson Run/Crafts Run
1131	Robinson Run #1	M-4	Robinson Run
1180	Robinson Run #13	M-4	Robinson Run
1180	Maidesville Lazelle Tipple	M-4	Robinson Run
1180	Jack Korson	M-4	Robinson Run
1181	Lazzelle Landslide, Tipple & Highwall	M-4	Robinson Run
1181	Robinson Run #12	M-4	Robinson Run
1182	Robinson Run Highwall	M-4	Robinson Run
1788	Robinson Run #5	M-4-B	UNT #1 Robinson Run
1789	Robinson Run #6	M-4	Robinson Run
1977	Murphy	M-4	Robinson Run
3829	Bowlby Highwall	M-4	Robinson Run
4180	Bethel Portals	M-4	Robinson Run
4421	Concorde Corporation	M-4	Robinson Run
4437	Korzun Subsidence	M-4	Robinson Run
4569	Robert Crites	M-4	Robinson Run
4570	James E Landsburgier	M-4	Robinson Run
4571	Gilbert Lazelle	M-4	Robinson Run
4909	Rt 100 (Commodore) Landslide	M-4	Robinson Run
5209	Maidsville (Nowakowski) Subsidence	M-4	Robinson Run
5736	Route 100 (Davis) Subsidence	M-4	Robinson Run
5865	Maidsville (Tennant) Landslide	M-4	Robinson Run
5938	Robinson Run (Cale) Mine Drainage	M-4	Robinson Run

Source: OSM (2005) and WVDEP (Various dates). Problem area numbers 1180 and 1181 were used for more than one AML.

APPENDIX B. LOADS FOR AMLS WITH WATER QUALITY PROBLEMS

Calculation of the pollutant load coming from a particular source requires information about the concentration of the pollutant in the water and the amount of water coming from the source in a particular amount of time. Both kinds of information are available at only one of the sources of AMD in the Robison Run watershed.

The Maiden #1 mine discharge, described in the PAD for Robinson Run Portals & Drainage (80), has been monitored a number of times (see Section 3.3). From these data, the average values reported from 2002 through 2004 in discharge monitoring reports were selected as representative of recent discharge water chemistry and flows. Loads shown in Table 15 were calculated by multiplying concentrations by flow and converting units.

Table 15: Load calculations for acid mine drainage pollutants

Parameter	Average value	Load (lbs/yr)
Flow	561 gpm	N/A
pH	3.2 standard units	N/A
Al	248 mg/L	610,000
Fe	925 mg/L	2,270,000
Mn	4.8 mg/L	11,800
Acidity	5,621 mg/L	13,800,000

Source: Average values from Table 7. Loads calculated

This water issues from a mine pool in the Pittsburgh coal seam. A second AML, Crafts Run (546), has a large discharge (300 gpm) and a pH close to 3, both of which are consistent with a discharge from a mine pool. Furthermore, this site lies downhill from the down-dip side of a Pittsburgh coal seam mine. The same chemical composition is therefore applied to this flow. Loads for the Crafts Run site are calculated by scaling the loads from the Maiden #1 discharge to a flow of 300 gpm.

The third AML with both flow and chemistry data is Robinson Run #6 (1789). This site also drains from a portal, but the pH value is 4. The chemical composition of this water was therefore assumed to be one-tenth as concentrated as that coming from the Maiden #1 mine discharge, which has a pH close to 3. The PAD provides an iron concentration of 20 mg/L, which is much less than one-tenth of the iron concentration measured at the Maiden #1 mine discharge. However, this measurement would have been made with a portable iron kit. Such kits usually have concentration ranges only as high as 10 mg/L, so it is likely the result in the PAD is not accurate. The load for this site is calculated by dividing the Maiden #1 mine discharge load by 10, for the concentration, and then scaling by 20/561 to account for the smaller flow.

APPENDIX C. DETAILED COST CALCULATIONS FOR AMLS WITH WATER QUALITY PROBLEMS

Water discharging at the data-rich AML sites is acidic and, based on the assumptions made in Appendix B, contains substantial amounts of aluminum. Therefore, the best passive treatment for the water would be RAPSs (Watzlaf et al., 2004). These systems, however, do little to lower Mn concentrations. Costs for these sites, therefore, include RAPSs and MRBs, in addition to costs for project management and engineering designs.

In this report, RAPSs are sized according to two parameters, flow and acidity, using the “Vertical Flow Pond” (VFP) module in the computer program AMDTreat (OSM, 2002). This module allows a number of sizing methods. The one chosen was “VFP based on Alkalinity Generation Rate.” The default alkalinity generation rate of 25 g m^{-2} day^{-1} (as $CaCO_3$) was used. Conditions for cost determination included:

- No liner for the system,
- No clearing and grubbing, and
- Standard piping costs.

AMDTreat was also used to determine the size of an MRB. MRBs were sized to provide a 24-hour retention time.

Land reclamation, construction of limestone channels, and portal seals to control the flow of the water are usually crucial elements of AMD remediation. However, those measures were not included in this plan. Two of the sites have already been reclaimed. The third, the Maiden #1 mine discharge, requires no land reclamation and is too large and too close to the receiving stream for open limestone channels to account for a significant part of the reclamation cost.

Costs for reclamation of the Robinson Run data-rich sites are compiled in Table 16. Costs are rounded to the nearest $10,000. Passive systems, such as RAPS, carry a certain risk of failure. The larger and more expensive the passive system is, the more unacceptable that risk becomes. Therefore, a ceiling of $1,000,000 per site is observed. This ceiling may represent the amount spent to establish an active treatment plant instead of a RAPS and MRB. If such a system is installed, funding for operations and maintenance would have to be found from sources other than the 319 program, which is currently limited to capital costs.

Table 16: Cost calculations for each abandoned mine land that discharges acid mine drainage

Site	Acidity (mg/L)	Flow (gpm)	Data source	RAPS	MRB	Design and project management	Total	Final cost
Robinson Run Drainage & Portals (80)	5,621	560	Discharge monitoring reports	$31,800,000	$250,000	$6,410,000	$38,500,000	>$1,000,000
Crafts Run (560)	5,621	300	Flow estimated in PAD, chemistry from site 80	$17,100,000	$130,000	$3,440,000	20,650,000	>$1,000,000
Robinson Run #6 (1789)	562	20	Flow estimated in PAD, one-tenth of the concentration in site 80	$120,000	$0[a]	$20,000	$140,000	$140,000

Note: The Robinson Run Drainage and Portals (80) includes the Maiden #1 mine discharge. [a]According to the assumptions in Appendix B, the concentration of Mn in the water discharging from this site is low enough that no treatment for Mn is necessary.